Initial scientific results from the cruise SO201-KALMAR: volcanology and petrology

Portnyagin M[1,2], Hoernle K[1], Werner R[1], Hauff F[1], Maicher D[1], Yogodzinski G[3], Baranov B[4], Silantiev S[2], Wanke M[1], Krasnova E[2] , Bogaard, Cvd[1]

[1] Leibniz Institute of Marine Sciences, IFM-GEOMAR, Wischhofstr. 1-3, 24114 Kiel, Germany

[2] V.I.Vernadsky Institute of Geochemistry and Analytical Chemistry RAN, Kosygin St. 19, 119991 Moscow, Russia

[3] Department of Earth & Ocean Sciences, University of South Carolina, 701 Sumter St., EWSC617, Columbia SC 29208, USA

[4] P.P.Sirshov Institute of Oceanology, Nakhimovski Prospekt 36, 117997 Moscow, Russia

The research project SO201 KALMAR included investigations of volcanic and tectonic structures and dredging of basement rocks in the NW Pacific and Bering Sea, the areas adjacent to the Kamchatka-Aleutian Arc junction and located within three lithospheric plates of different provenance and evolution (Pacific, Okhotsk and North American Plates). This research has carried out within the KALMAR project and aimed at reconstructing of temporal and compositional evolution of volcanism at the Kamchatka-Aleutian junction. Major goals for the marine research with R/V SONNE were to collect information about the age and composition of the NW Pacific oceanic crust subducting beneath Kamchatka and Aleutian Arcs, to study the extent and compositional peculiarity of young submarine volcanism along the Western Aleutian Arc and to explore the origin and evolution of Bowers and Shirshov Ridges in the Bering See.

Multi-beam mapping of the ocean floor and dredging to obtain submarine volcanic samples were carried out during Leg 1b (10.06.-06.07.2010) and Leg 2 (30.08.-08-10.2009) of SO201 KALMAR expedition (Fig. 1). A total of 74 dredges were carried out. Of these deployments 72 (or 97%) recovered rocks with 65 of them (or 87%) clearly sampling in situ magmatic or sedimentary rocks. The basement rocks were recovered from three major areas of study: (1) NW Pacific oceanic crust including northernmost Emperor Ridge Seamounts and oceanic floor to the north of them, (2) young submarine volcanoes along the Western Aleutian Arc, and (3) Shirshov and Bowers Ridges in the Bering Sea. In most areas magmatic rocks were sampled for the first time and thus provide invaluable information about the origin of magmatic provinces in the NW Pacific.

Magmatic rocks of the NW Pacific oceanic crust were dredged along the Emperor Ridge, at seamounts northwest of the ridge and from the Pacific Plate adjacent to the Aleutian Trench (Fig. 1). Emperor Ridge was sampled at Hanzei, Suizei and Tenji Seamounts and also from the northernmost Meiji Seamount, where only scarce and strongly altered rocks were recovered before at the DSDP Site 190. Ongoing geochemical research and absolute age dating of these rocks will help constrain the age of the Hawaiian hotspot and its evolution during the early Cretaceous and will contribute to paleo-reconstructions of the NW Pacific since the Cretaceous Quite period.

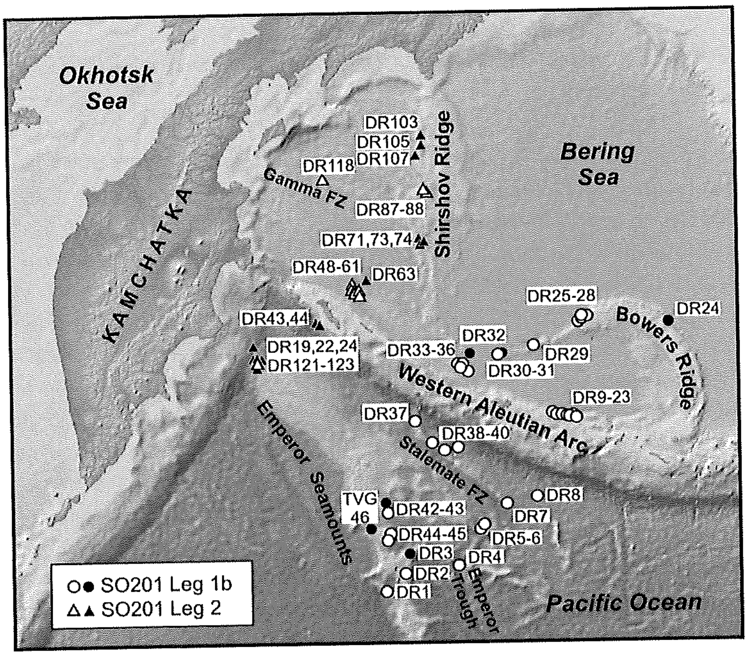

Fig. 1.: Locations of dredge (DR) and TV-grab (TVG) stations during SO201 KALMAR Legs 1b and 2. Open symbols denote stations where in-situ magmatic rocks were recovered, solid symbols - stations with sedimentary or metamorphic rocks.

We were successful at sampling the Pacific sea-floor basement at the Emperor Trough, the fossil Kula-Pacific Rift and the Stalemate Fracture Zone. A particularly broad spectrum of rocks including serpentinites, gabbro, dolerites and lavas were sampled along the Stalemate Fracture zone (Fig. 1). These rocks are thought to represent a complete section of oceanic lithosphere formed at the fossil Kula-Pacific spreading center. A study of these rocks will allow us to reconstruct the conditions of magma generation responsible for the formation of the NW Pacific oceanic crust and also to characterize the input into the Western Aleutian subduction zone. First petrographic and mineralogical data obtained on serpentinites from Stalemate FZ (Krasnova et al., 2011) suggest that these rocks range in composition from moderately depleted lherzolites to dunites and represent disintegrated fragments of depleted lithospheric mantle variably re-fertilized by melt percolation. Major and trace element compositions of relict spinel and pyroxenes from these rocks indicate significant difference in the physical and chemical conditions of magma generation at the Kula-Pacific Ridge compared to the present-day conditions at the East-Pacific Rise.

The Western Aleutian Arc is unique in the global systematics of subduction zones because of very oblique convergence of the Pacific Plate and therefore unusual conditions of magma generation. The extensive sampling of submarine volcanoes carried out during SO201-KALMAR cruises largely fills the gap in our knowledge about the spatial and compositional distribution of volcanism in the Western Aleutian Arc. The dredging was carried out in the Ingenstrem Depression, west of Attu Island and at the Volcanologists Massif (Fig. 1) and complements previous sampling campaigns during R/V Thompson (2005) and R/V Volcanologist (1985-1990). The discovery of young volcanic edifices west of Attu Island during the SO201-KALMAR Leg 1b clearly proves that active volcanism is present along much of the length of the Aleutian Arc and that the Aleutian Volcanoes define one magmatic arc, continuous from the tip of Alaska Peninsula in the east to the Piip Seamount in the west.

Our study on the new collection of volcanic rocks from the Volcanologists Massif has focused on major and trace element and isotope geochemistry of volcanic glasses and on the composition of high-Mg olivine phenocrysts and melt inclusions in them. The results provide new information on the composition of parental magmas of the Volcanologists Massif, composition of their mantle sources, P-T conditions of mantle melting and regime of volatile components. Our preliminary data suggest that there is a temporal progression in magma composition from MORB-like at the base of the volcano and its flanks to magmas with strong subduction-related signature on the Piip Seamount. These results provide new constraints on the origin of the Volcanologists Massif and suggest a significant (>100 km) advance of the Aleutian Trench in the northern direction during the Quaternary, changes in the slab dip or migration of the Volcanologists Massif closer to the trench so that the distance from the massif to subducting plate shortened and the amount of slab-derived fluid in the mantle wedge increased through time (Portnyagin et al., 2011).

Dredging in the Bering Sea was successful at the NE flank of the Bowers Ridge, at several stations along the Shirshov Ridge, seamounts between these ridges and at the Gamma Fracture Zone in the Kommandorsky Basin (Fig. 1). The rocks dredged at the Bowers Ridge are the first basement samples from this large aseismic structure in the Bering Sea and provide direct insights into its origin. The preliminary geochemical data strongly support an island-arc origin of the Bowers Ridge. Rocks from Shirshov Ridge are more diverse and include green shists and island-arc type volcanics of two different series. Geochemically distinctive volcanic rocks, which share many characteristics with Hawaiian shield tholeiites, were dredged from a seamount west of Bowers Ridge. The geochemical and petrological studies are currently in progress and together with Ar/Ar age data, presently being generated, will allow us to refine existing tectonic models on the origin and evolution of the Bering Sea (Wanke et al., 2011).

References

Portnyagin M., Hauff F., Hoernle K., et al. (2011) Geochemistry of primitive glasses from the Volcanologists Massif (Far Western Aleutian Arc) obtained during SO201-KALMAR (this volume).

Krasnova E., Portnyagin M., Silantyev S. , et al. (2011) Ultramafic rocks from the Stalemate Fracture Zone (NW Pacific) dredged during the cruise R/V Sonne SO201-KALMAR Leg 1b (this volume).

Wanke M., Portnyagin M., Werner R., et al. (2011) Erste Ergebnisse für die Zusammensetzungen der magmatischen Fundamente vom Bowers und Shirshovrücken (Bering See, NW Pazifik) (this volume).